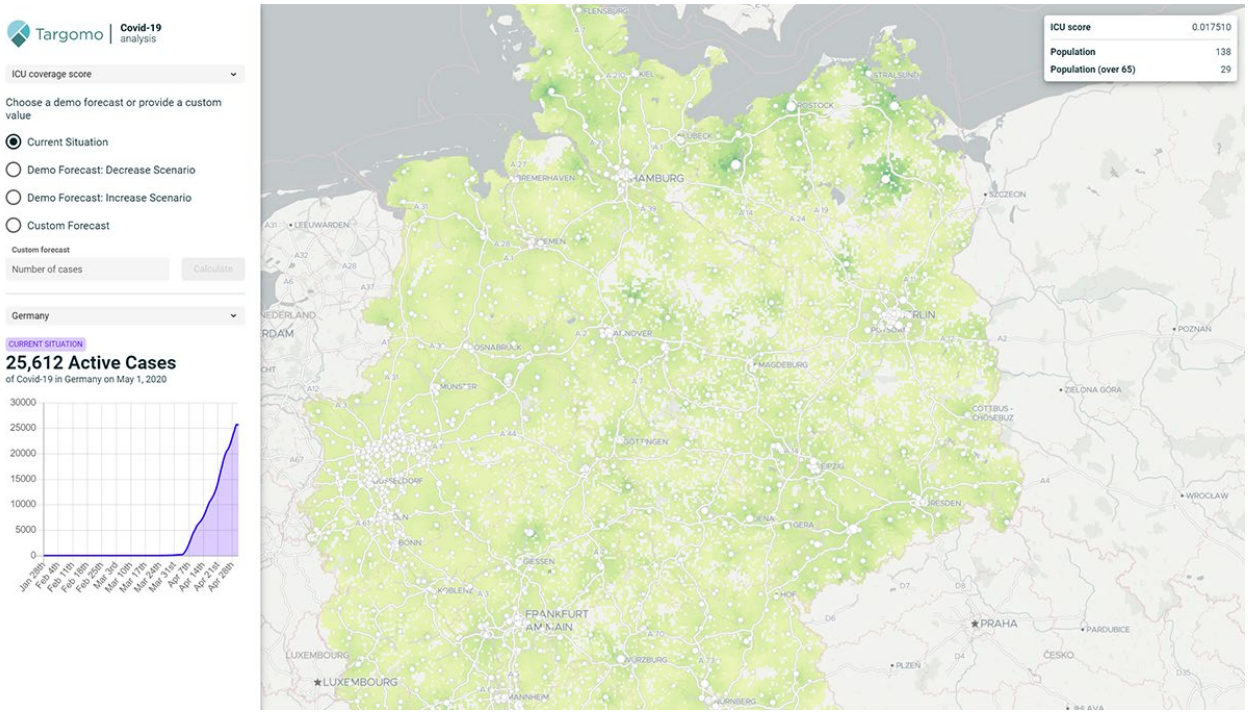
Berlin, May 5, 2020

Covid-19 pandemic management: Identify risk areas in intensive care capacities and expand coverage on time

The coronavirus outbreak has highlighted the need for sufficient capacities of intensive care (IC) beds. Targomo engineers have developed a tool to predict risk areas in IC capacities and take action before shortages occur. The analysis can be rolled out across nations and applied to other service coverage questions as well as different areas, such child care facilities, schools and public transport.



The covid-19 pandemic has led to a huge rise of intensive care patients who need extensive treatment in hospitals and clinics. The outbreak has forced some authorities to set up emergency hospitals or move IC patients to other regions or countries, where the virus had not yet infected many people.

Faced with this problem, Targomo data scientist Jacopo Solari and colleagues developed an analytical tool to calculate the need of IC beds or IC units at a local, regional and national level. They combined pandemic and hospital data with census figures and a reachability analysis to model demand for IC beds. Based on real-time data and assuming certain scenarios of how the outbreak could develop, they were able to predict where a shortage of IC beds could arise.

The tool, developed during an EU-backed hackathon on May 1-3, allows authorities and hospital operators to plan ahead and build up extra capacities before an outbreak expands or decide to move patients to less affected areas to free up IC beds. These steps can prevent ICU shortages, save lives and guarantee an adequate level of medical service locally and across the nation. The analysis won Jacopo and his team an award and €5,000 in prize money.

It is important to note the following: The analysis is not a prediction of future covid-19 cases in Germany, but merely a presentation of hypothetical outbreak scenarios. The current situation displays the actual, total number of active covid-19 cases in Germany, but the distribution of covid-19 patients who need intensive care treatment among hospitals is estimated. The number of intensive care patients shown only reflects the number of covid-19 patients who need ICU treatment. It does not include "normal" intensive care patients, meaning people who receive ICU treatment for different causes. The current situation is therefore not comparable to data shown by DIVI, Germany's association of intensive care specialists, which has collected all ICU data from individual hospitals in a so-called Intensive Care Register. DIVI's figures are subject to copyright laws and could not be included in the analysis without the organization's permission.

The following pages explain how the tool works in detail. Or, alternatively, watch the award-winning video pitch and get a brief introduction to the tool.

Data credits:

- Destatis, Germany's Federal Statistics Office:
    - Detailed demographic data, showing how many people of a certain age group live in certain geographic area
- Robert-Koch Institute, Germany's federal institute for public health and the central body to coordinate measures to contain the covid-19 outbreak:
    - Robert Koch-Institut (RKI), dl-de/by-2-0
- Information System of the Federal Health Monitoring, 2015 / Germany's Federal Statistics Agency (Gesundheitsberichterstattung des Bundes 2015 / Statistisches Bundesamt)
- Gemeinsamer Bundesauschuss, a federal agency which collects all types of data about Germany's hospitals and clinics:

    - Quality Report of Hospitals for the year 2017. The report was published in 2019.
    - The Quality Report of Hospitals has only partially been used. A comprehensive overview of the Quality Report of Hospitals can be found here: www.g-ba.de/.
    - Only three variables were used from the report: number of hospitals and their exact locations, total number of beds per hospital, whether a hospital offers intensive care treatment or not.
    - The Quality Report of Hospitals is used here in conjunction with other sources of information. Therefore, the recommendations and results given do not represent an authentic reproduction of the quality reports. For a complete presentation of the quality reports of hospitals, please refer to www.g-ba.de.
- OpenStreetMap / OSM Contributors:
    - Location and road data, and reachability analysis to calculate travel times from a home to a hospital

Combining data

The analysis builds on several data sets to calculate the number of IC beds needed in a region and nationwide:

- Real-time number of active covid-19 cases and an estimation of the fraction of infected people needing IC treatment. When available, actual figures of people in intensive care can be included in the analysis of the current situation.
- Geographic locations of a nation's hospitals and clinics offering intensive care treatment and the number of IC beds available per hospital.
- Census data, showing how many and where people live in a specifically defined location, known as census cell.
- Reachability analysis: routing data to predict in which hospital covid-19 patients will most likely receive intensive care treatment.

Reachability and census data

The reachability of hospitals is crucial for the analysis: Patients are most likely to receive treatment in medical centers that are nearby. Because time and quick help is essential to offer relief and increase chances of survival, covid-19 patients will most likely visit hospitals in their immediate vicinity.

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Combined with census data, which tells us how many people live in a certain region, the reachability analysis will show which hospitals will receive how many covid-19 patients. Simply put, locations that are nearby will attract more patients from their immediate vicinity. The tool assumes that covid-19 patients will drive a maximum of one hour to visit a hospital in their region.

The reachability analysis allows us calculate a so-called 'ICU coverage score' for each geographic area, which is defined as the area for which census figures have been collected. The latter is known as a census cell.

"We used reachability, or to be exact, the inverse of travel time to calculate which patients are 'drawn' to which hospital," says Jacopo Solari, who holds a Ph.D. in physics. "The further away a hospital is from a census cell, the less impact it will have on the score of that cell."

With their model, Jacopo and his team can calculate and visualize two important outcomes:

- The level of IC capacities or coverage score for each geographic cell. This shows whether people in an area (a census cell) have decent access to IC beds in their immediate surroundings. It is computed as the sum of the bed balances (number of IC patients - number of IC beds) for surrounding hospitals, divided by their travel time.
- The number of covid-19 patients in need of IC treatment for each hospital. It answers whether a hospital has enough IC beds available or not to treat covid-19 and other patients, who need intensive care treatment.

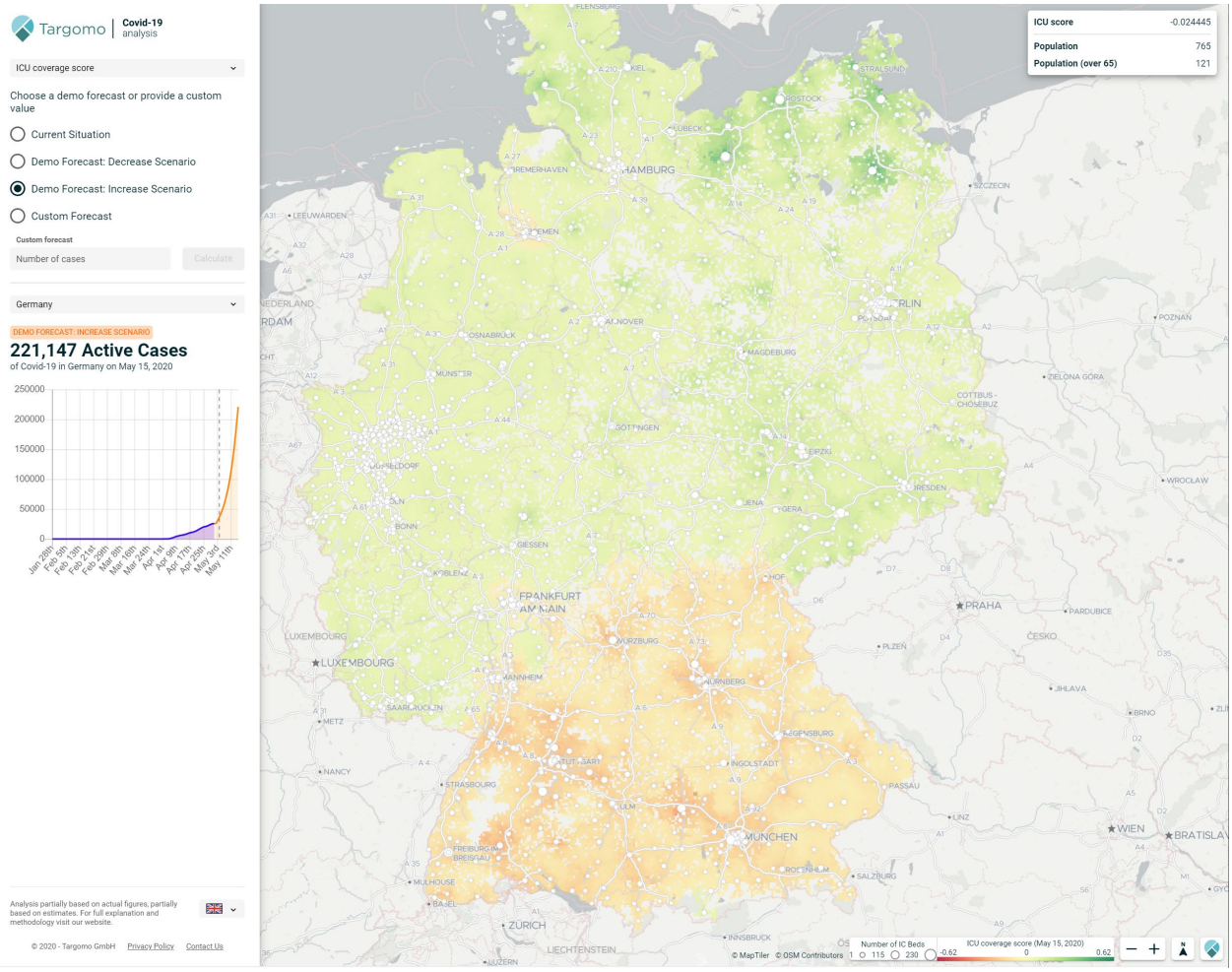
Visualize scenarios and take action

The tool will show on a map where IC coverage is sufficient, near its limit or inadequate. For Germany, the current situation is reassuring as the number of covid-19 patients needing IC treatment is well below available IC beds across the nation, as depicted in the picture at the top.

The tool's value becomes evident when different scenarios are analyzed, specifically the ones where the number of covid-19 cases, and, subsequently, the number of people in need of intensive care treatment, rises dramatically.

The map below shows how the German states of Bavaria and Baden-Württemberg would lack the capacities to treat covid-19 patients, who need intensive care help. Visualization helps to immediately identify the risk areas. As an additional aid,

demographic details for each census cell are highlighted in the top right corner: total population at a location and the number of people over 65.

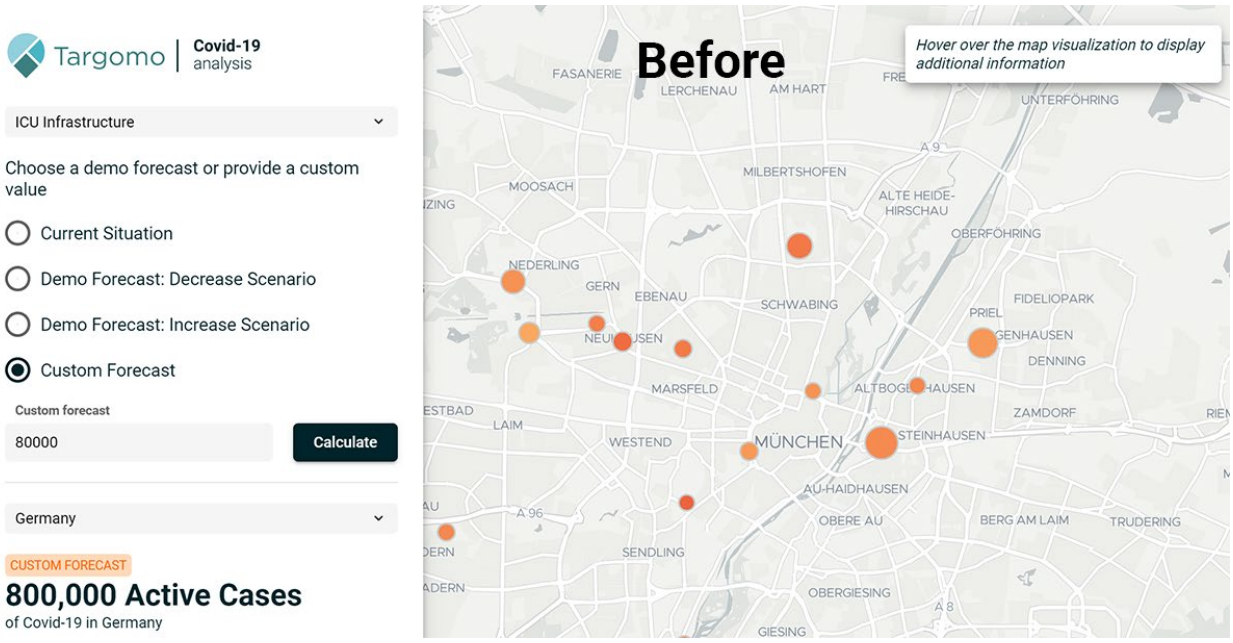


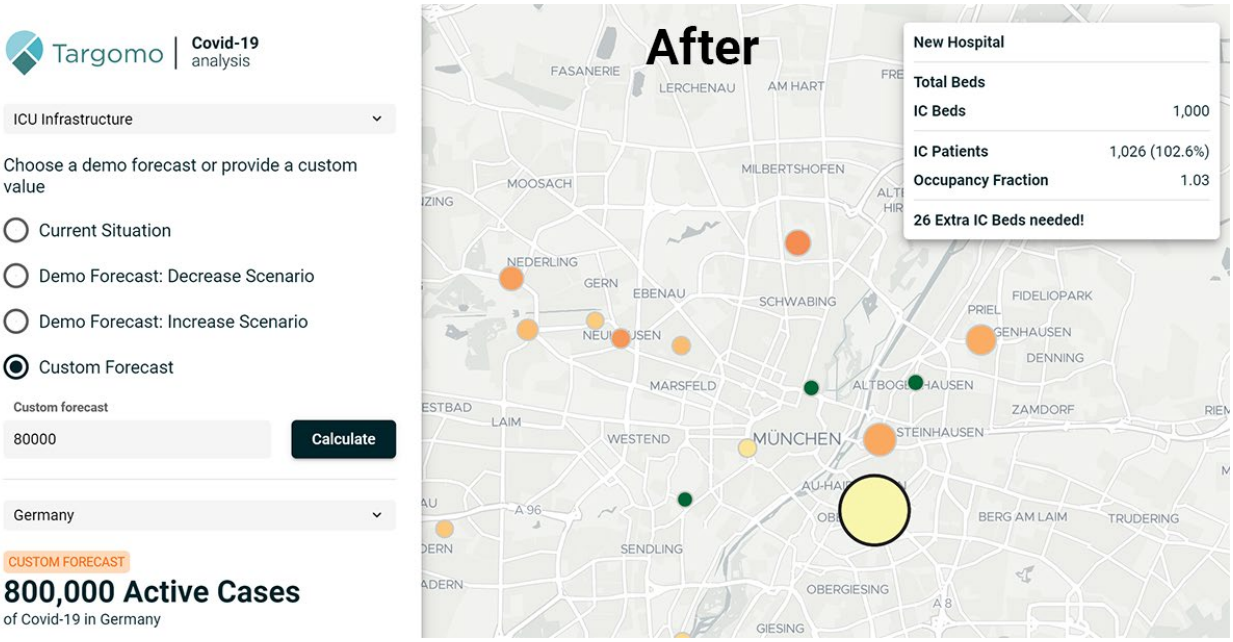
Map showing ICU coverage score for Germany assuming a scenario of an increase in the number of active covid-19 cases. G-BA's Quality Report of Hospitals has only partially been used. A comprehensive overview of the Quality Report of Hospitals can be found here: www.g-ba.de/. The Quality Report of Hospitals is used here in conjunction with other sources of information. Therefore, the recommendations and results given do not represent an authentic reproduction of the quality reports. For a complete presentation of the quality reports of hospitals, please refer to www.g-ba.de.

Analyze individual hospitals

The tool is also powerful at the hospital level. The map allows users to toggle between the ICU coverage score (the map is colored) and individual hospital, displayed by the

dots on the map. Once hospitals are visible, users can see how many IC beds each hospital has and whether there is shortage of beds or not. Users can add a new, temporary hospital to see how this would improve the situation, as shown in the two pictures below.





G-BA's Quality Report of Hospitals has only partially been used. A comprehensive overview of the Quality Report of Hospitals can be found here: www.g-ba.de/. The Quality Report of Hospitals is used here in conjunction with other sources of information. Therefore, the recommendations and results given do not represent an authentic reproduction of the quality reports. For a complete presentation of the quality reports of hospitals, please refer to www.g-ba.de.

The tool also allows users to pick a random outbreak scenario by entering the number of active covid-19 cases in a country, in the example, Germany. Epidemiologist can use the 'Custom forecast' option to put their own predictions into the tool. They can then instantly visualize the effect of their own state of the art disease-spreading model.

Scalable: Broader use cases

The analysis does not only apply to ICU service quality, but for any type of medical service, such as the number of places to treat people with heart problems or geriatric ailments. By changing the data sets, the same analysis and insights can be obtained. The tool also allows users to analyze service quality questions outside the medical realm, for instance the number of child care or school places in a city, whether the quality of education is deemed sufficient (as measured by exam scores).

International use is also easily feasible, by taking data from other countries or regions. For instance, if the state of New York has data available, the analysis could be made in a couple of hours. The analysis can be made for any country in the world as long as the necessary data is available.

Methodology

Jacopo and his team have used different data sources for the analysis. A full list is given further down, but the most important data sets are the number of covid-19 cases provided by Germany's federal health institute, or Robert-Koch Institute, and an estimation fo the number of intensive care beds per hospital. The latter figure is derived from the number of ICU beds per German state and then proportionally allocated to each hospital in a state, by dividing it by the total number of beds in that state. It is assumed, that the number of intensive care beds is linearly related to the total number of (normal) hospitals beds.

The analysis assumes that a certain number of covid-19 patients needs intensive care treatment. Currently, this number is set at 0.0075, meaning that 0.75% of active covid-19 cases end up in hospital. This number is based on the most up-to-date figure from the Robert-Koch Institute.

Data sources:

- Destatis, Germany's federal statistics office:
    - detailed demographic data, showing how many people of a certain age group live in certain geographic area
- Robert-Koch Institut, Germany's federal institute for public health and the central body to coordinate measures to contain the covid-19 outbreak:
    - number of cases over time per at the state level
- Gesundheitsberichterstattung des Bundes
    - Number of ICU beds per state (Bundesland)
- Gemeinsamer Bundesauschuss, a federal agency which collects all types of data about Germany's hospitals and clinics:
    - Number of hospitals and their exact locations
    - Total number of beds per hospital
    - Whether a hospital offers intensive care treatment or not
- OpenStreetMap:
    - location and road data, and reachability analysis to calculate travel times from a home to a hospital

The analysis would improve if DIVI, Germany's association of intensive care specialists, would grant access to its real-time data of all intensive care units in Germany. DIVI has collected an overview of all of total available IC beds and occupied beds in Germany and updates the list daily.

About Targomo:

Bringing together advanced location analytics, artificial intelligence and big data, Targomo helps organizations generate data-based insights and forecasts to boost performance. Founded in 2013 and based in Berlin and Potsdam, Targomo offers location intelligence solutions that convert complex geospatial research into actionable insights. These allow customers to optimize their retail networks and predict performance, deliver better public services, and to improve real estate search and logistics routing. More information: www.targomo.com

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